2023

Development of 3D and 360 GIS-Based Models to Visualize Projected Sea Level Rise in Coastal Virginia

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A capstone project in partial fulfillment of the requirements for the degree of Master of Arts in Marine Science at the Virginia Institute of Marine Science, William & Mary

2 August 2023

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Capstone products:

Accessibility Tips for Scientific Presentations: https://go.wm.edu/b6g7S5
3D Map of Norfolk Sea Level Rise Projections: https://go.wm.edu/QdYPGq
360 Scene of Norfolk Sea Level Rise Projections: https://go.wm.edu/j9mgFQ

Introduction

Science communication is a skill that can be strengthened with practice. Like any skill, it helps to know what you need to practice in order to get better at it. When presenting information to an audience, the skill of science communication comes into play as early as the first draft of a presentation. As you think about how you will tell your story to the audience, you likely consider including text on slides, images, graphs, maps, or even videos. However, it is crucial to remember that accessibility barriers are something we must often consciously work to rid our presentations of, in order to make sure we are telling the same story to everyone in the audience.

How you present your research inherently determines the way in which your audience learns and engages with that information. If a presentation has many accessibility barriers, it can lead to an incomplete picture forming for members of your audience. For instance, if a member of your audience experiences colorblindness, they may not be able to get a full understanding of your charts, maps, or graphs depending on your color choices. Individuals that have difficulty with hearing may not be able to clearly perceive your take home messages without captions or clear points in easily readable fonts. Doing something small like enabling captions in your presentation can help more than just those that are hard of hearing follow along, but also audience members who use visual assistance with auditory processing or who do not have the same native language as the one in which you are presenting (Cooke et al., 2020).

This project is going to dive into one of the examples from earlier: maps. Maps used in the scientific community for disseminating information to general audiences have historically been two dimensional, with some exceptions. However, thanks to the ease of access to rapidly evolving technology, turning the story of your spatiotemporal data into a 3D map with 360 visualization that tells a more powerful story to your audience is becoming more common. One use example of this is modeling projected sea level rise (SLR) in coastal communities, which will be the focus of this capstone.

The incorporation of 3D maps and 360 visualizations in city planning has been successfully implemented in places across the globe including Hamburg, Germany, where the harbor is particularly at risk (Chen, 2011; Sterr, 2008). In Virginia, the low lying coastal areas have seen flooding at an accelerated rate, which indicates that SLR inundation is a future challenge for the low elevation infrastructure and the communities that reside in these regions (Mitchell et al., 2021, Sanford et al., 2009). Many cities are choosing to face and adapt to the challenge of SLR head on through comprehensive strategies of resilience for their communities. While Norfolk is doing the same, it is important to also have a historical lens when planning in communities, and planning for SLR adaptation is no different.

Though many in Virginia will be impacted by SLR, historical context is particularly important in this area due to redlining, or the discriminatory practice of neighborhoods being considered “financially risky” due to their ethnic make up by banks, that occurred in Norfolk and beyond. These historically marginalized and socioeconomically disadvantaged areas of communities are seeing higher risks of environmental related concerns, such as rising temperatures and more frequent flooding (Salazar-Miranda et al., 2023).

Making science inclusive and accessible by limiting as many barriers as we can will have a positive impact on our stakeholders, communities, and city planners. The goal should be easy interpretation of results that tell a clear story, especially with SLR in coastal Virginia. Having a 3D visual aid that allows stakeholders to plainly see water depth on roads and buildings will be more easily interpreted than a 2D map with no third dimensional context. This will help community members of all backgrounds be better informed about potential future SLR risks for them and their loved ones. The purpose of this project was to create products that would make scientific presentations more inclusive and present our SLR data in an impactful, inclusive, and accessible way that also highlights the impacts on redlined areas within the city of Norfolk, Virginia.

Methods

Accessibility Tips Reference Guide

The information used to create the guide was sourced from multiple resources about accessibility and inclusivity. Tips were chosen based on ease of implementation and with covering a variety of needs in mind. These tips include: leaving space on the bottom of your slides for captions to appear, checking your visual aids (maps, graphs, etc.) in a color filter to ensure your color choices do not look similar to those with colorblindness, enabling captions for participants when possible, and using inclusive language while avoiding jargon. Creation of the guide was done in Canva. Tips were broken into two categories: crafting the presentation and presenting the presentation. The one-pager lists out five tips in each category to help users craft a more inclusive presentation. This guide is not meant to be, and is in no way, an exhaustive list of things that can be done to make a presentation as inclusive as it can be. It is meant to act as a starting point for presenters in thinking about simple ways they can tell a more complete story to their audience. The reference guide is available here (https://go.wm.edu/b6g7S5).

3D Maps and 360 Scenes

The Center for Coastal Resources Management (CCRM) at the Virginia Institute of Marine Science (VIMS) has SLR projections through 2100 for the AdaptVA tool. These data can show 4 different scenarios of inundation: low, intermediate, intermediate high, and extreme. These are different from the NOAA SLR projections. This project uses the intermediate, intermediate high, and extreme scenarios for projections at 3 timestamps- 2020, 2050, and 2100.

These scenarios, which are also called depth rasters, along with the CCRM digital elevation model (DEM) were clipped to the Norfolk city limits, as provided on the Norfolk Open GIS Data website. The DEM was added to each depth raster to create nine water surface elevation (WSE) layers. From the WSE layer, a 3D flood level was created. Data were reprojected in meters above mean high high water (MHHW). The 3D WSE polygon was then exported as a web layer and published on ArcGIS Online (AGOL).

The 3D building structures were created from the US Structures polygon file provided by FEMA by extruding the polygons based on height attributes. The Norfolk redline file was adapted from the Home Owners' Loan Corporation (HOLC) file from Craig McCabe, accessed via the Esri database. The HOLC file was created based on the historic redlining maps for Norfolk. People were created as points in target areas of D and C grade neighborhoods that would experience SLR inundation to help better give context to the visualizations. All of these files were edited in ArcGIS Pro and then exported as web layers to AGOL.

All of the layers were compiled into the Norfolk SLR VIMS/CCRM Data Global Web Scene and the appropriate symbology and grouping was applied. The map was published as public and is available for viewing here (https://go.wm.edu/QdYPGq).

Creation of the 360 scenes were done in the Web Scene by creating slides at areas of interest, based on the people in the neighborhoods. The collection of scenes was then exported as a 360 VR app using the tools in the Web Scene. These are able to be edited and updated at any time. The 360 VR scenes are available here (https://go.wm.edu/j9mgFQ).

Conclusion

Scientists must take care to ensure the information they are presenting tells a complete story to those in their audience. This can be achieved through implementing as many accessibility tips as possible for each presentation and seeking out ones from reputable and trusted sources that are not listed, such as the Studio for Teaching and Learning Innovation at Willian & Mary.

Some software have accessibility checkers built in, and they are becoming more common. AcrGIS Pro, for example, has the ability to toggle color filters on your scene so you can see what your map looks like to those with different types of colorblindness. Many computers now have color filters built in that you can enable in the computer's settings and to check your work. Zoom has built in captions that can be enabled for participants and once enabled each person that joins can turn them on or off on their personal screens. Technology is making it easier than ever to make your presentation more inclusive and accessible for your audience. Keeping up with the feature updates of the software and hardware you use will help you have more powerful presentations.

The ability to project spatial and spatiotemporal data in 3D and 360 formats makes the information have a stronger emotional appeal and helps audiences more fully understand the impact of the information. For SLR this helps better visualize the inundation to communities and allows city planners to see projected water levels with the context of height, while having the ability to incorporate historic redlining and seeing the estimations for those areas of the community.

This context is also more powerful for the general public, as seeing a person with water around them in their neighborhoods is a much different perspective than a 2D map that has blue water lines on it. The combination of 2D and 3D data allows people to have a much better understanding of what projected SLR will look like, and will likely encourage a stronger response.

Clear communication and strong storytelling should be a goal of all scientific presentations. Using the resources created for this project will help you better navigate the introduction of inclusive presentations and the rapidly growing world of 3D and 360 data. Using the guide will limit the number of one time accommodations you may need to make and remove the need for members of your audience to disclose the need for the specific accommodation. Presenting SLR data in 3D and 360 formats that are available online and can be accessed across the globe tells a universal visual story that transcends language. This makes the projections less intimidating and more easily navigable for those that are not as familiar with 2D inundation maps, telling a more complete and approachable story, which should be the goal for all scientific findings.

Acknowledgements

I would like to thank Dr. Molly Mitchell for her insightful guidance during the process of the M.A. program. I would also like to thank Dr. Kirk Havens for his knowledge and support, especially during the evolution of this capstone. To my professional mentors, Keith VanGraafeiland and Craig McCabe: I am very grateful for your time, patience, and wealth of knowledge that you shared with me. Without both of you this project would not have been possible. A special thank you goes to Dr. Dawn Wright, Chief Scientist at Esri, for her recommendation of Keith and Craig as my advisors. Thank you to Dr. Tara Cox and Dr. Chris Hintz at Savannah State University for inspiring this project and supporting my undergraduate education. To the Global Research Institute at William & Mary and its Director Dr. Michael Tierney- thank you for being a supportive community and encouraging the continuation of this research beyond this capstone. Thank you to my friends and family that have supported me throughout my education in a multitude of ways. An immense thank you to the other students of the inaugural VIMS M.A. in Marine Science cohort. You are all amazing and it has been an honor to spend this time with you. I know you have amazing things in store for your lives. To those of you who are still reading to the end, thank you for taking the time to read something I am extraordinarily passionate about and I hope it helps you tell your story in a more complete way, wherever that story may be.

References

Chen, Ran. “The Development of 3D City Model and its Applications in Urban Planning.” Proceedings - 2011 19th International Conference on Geoinformatics, Geoinformatics 2011. 1-5. 10.1109/GeoInformatics. 2011.5981007. (2011).

Cooke, Michele L., et al. "Caption This! Best practices for live captioning of jargon-rich scientific presentations." Authorea Preprints (2022).

Mitchell, Molly, Robert E Isdell, Julie Herman, and Christine Tombleson. “Impact Assessment and Management Challenges of Key Rural Human Health Infrastructure Under Sea Level Rise.” Frontiers in Marine Science 8 (2021).

Salazar-Miranda, Arianna, Toàn Phan, and Jeremy Hoffman. "Long-term Causal Effects of Redlining on Environmental Risk Exposure." (2023).

Sanford, W.E., Pope, J.P., and Nelms, D.L. “Simulation of groundwater-level and salinity changes in the Eastern Shore, Virginia: U.S. Geological Survey Scientific Investigations Report.” 2009–5066, 125 p. (2009).

Sterr, Horst. "Assessment of Vulnerability and Adaptation to Sea-Level Rise for the Coastal Zone of Germany." Journal of Coastal Research 24.2 (2008): 380-393.